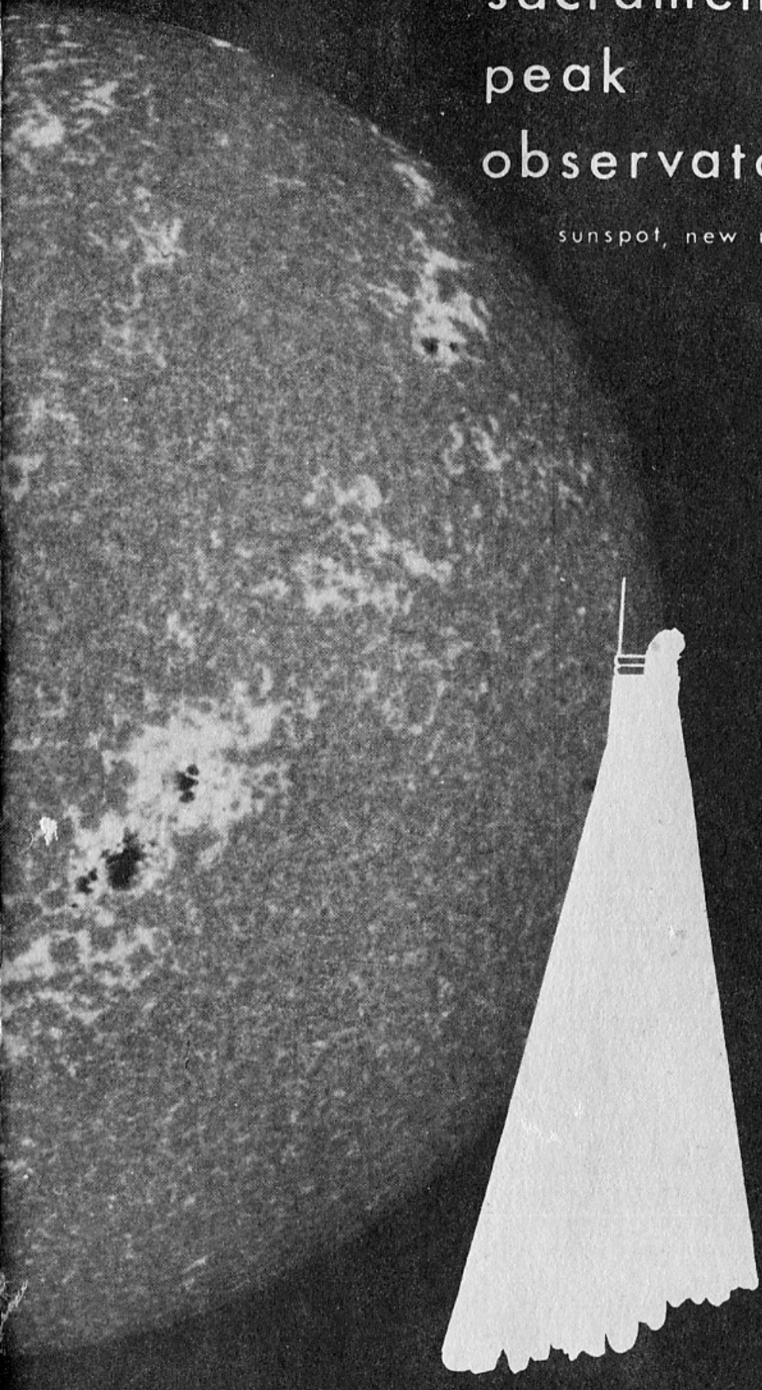
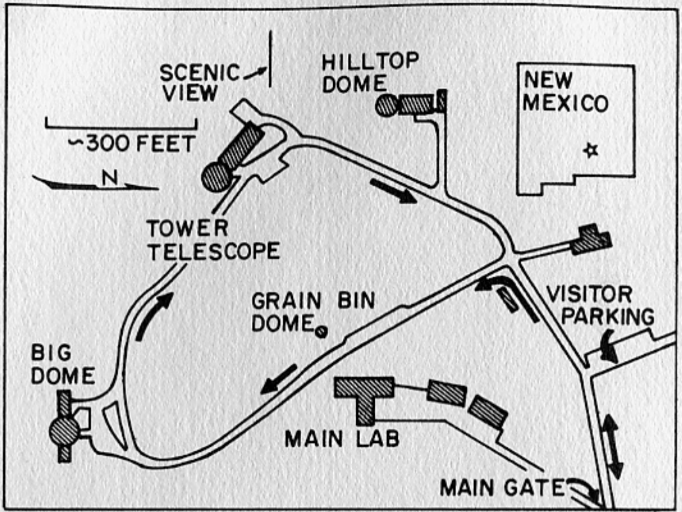
sacramento peak observatory

sunspot, new mexico





Map Key

FRONT COVER: a silhouette of the Tower Telescope appears against a picture of the lower atmosphere (chromosphere) of the sun. The two irregular bright bands are the zones in which sunspots and flares appear. The largest sunspot is as large as the earth.

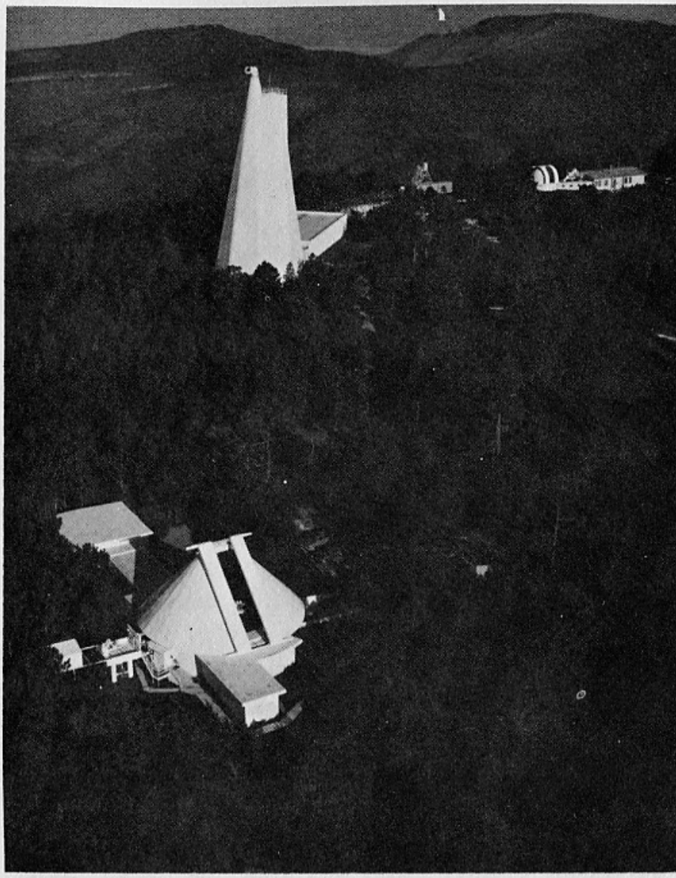
SACRAMENTO PEAK OBSERVATORY
SUNSPOT, NEW MEXICO

SELF-GUIDED TOUR

On behalf of the United States Air Force, welcome to Sacramento Peak Observatory. This installation is a solar research laboratory under the direction of the Air Force Cambridge Research Laboratories, part of the Air Force Systems Command.

THE SELF-GUIDED TOUR

The tour begins at the "VISITORS" sign across from the entrance to the visitors' parking lot. In walking around the observatory grounds, please refer to the map for directions and watch carefully for the directing signs along the way. If you are not accustomed to the altitude, you should stop often and rest during the tour. You may take pictures (including flash) unless signs forbid it. PLEASE DO NOT SMOKE WHILE ON THE TOUR! A forest fire here would be disastrous. RESTROOMS and drinking water are located back down the entrance road in a small, green, cement-block building, No. 3060, near the gate.

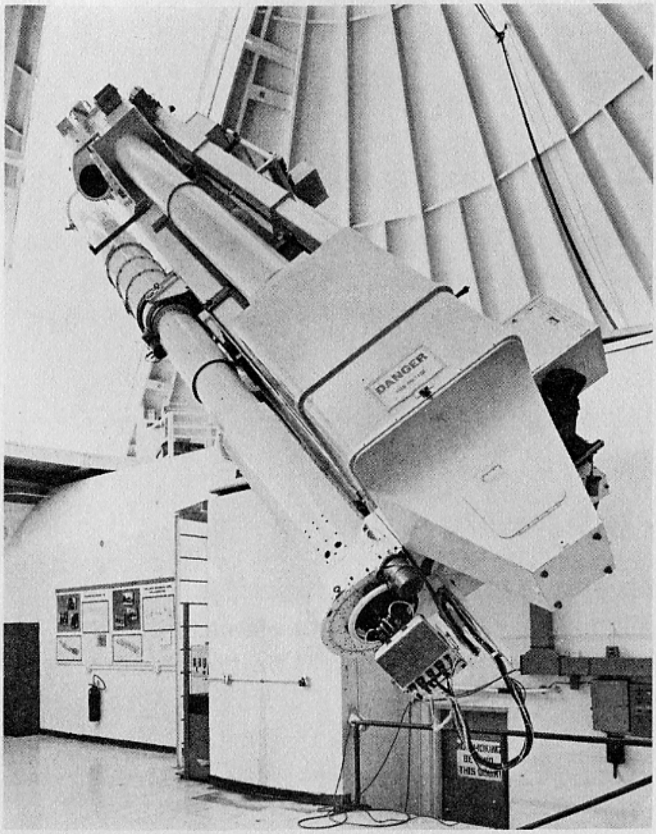


The Tower Telescope dominates the horizon of Sacramento Peak Observatory, with the Big Dome in the foreground and the Hilltop Dome in the background.

THE OBSERVATORY

Sacramento Peak Observatory is located in the Lincoln National Forest at an elevation of 9200 feet above sea level. At this altitude we are above 30 percent of the earth's atmosphere. The dry air of the Southwest and the isolation from any major sources of air pollution make this an excellent observing site. Sacramento Peak employs some 70 people, most of whom live on the peak year-round with their families. Children are bussed to school in Cloudcroft and shopping is done in Alamogordo. The average annual rainfall is 17 inches, coming mostly in July and August. The average snowfall is 72 inches. The temperature only rarely goes above 85° or below zero.

The purpose of Sacramento Peak Observatory is twofold. First, we provide to the Air Force information on the causes of solar-induced effects on their operating systems and possible methods for predicting them. The strongest effects are caused by solar "flares," huge explosions on the surface of the sun that release into space radio waves, x-rays, visible light, and high-speed atomic particles. These affect the earth and its environment, causing radio interference, magnetic storms, and the aurora or Northern Lights, interfering with the operation of satellites and endangering the safety of astronauts in space. We, therefore, are striving to understand flares by investigating all related phenomena on the sun. In addition, we utilize our skills in the various fields of physics to assist the Air Force in the design, construction and improvement of its operating systems.



The Big Dome spar carries several telescopes, all of which may be operated simultaneously.

SOLAR INSTRUMENTS

All the instruments at Sacramento Peak are designed especially to study the sun. Three of the most common types of solar instruments are coronagraphs, spectrographs, and simple telescopes with cameras attached.

Coronagraphs allow us to study the sun's thin outer atmosphere, called the corona. Normally the corona is only visible during total eclipses of the sun, when the moon moves between the earth and the sun, blocking out the solar surface. Total eclipses occur less than once per year, often in remote and inaccessible locations, and then last but a few minutes. With the coronagraph, the bright portion of the sun's image is blocked by a metal disk, producing an artificial total eclipse and allowing detailed studies of the corona over long periods of time.

When sunlight is passed through an ordinary prism it is broken up into its component colors: red, orange, yellow, green, blue, and violet, called a spectrum. This is the principle on which a spectrograph operates. At different colors, corresponding to light of different wavelengths, we observe bright or dark lines in the spectrum. These lines are like fingerprints, telling us which elements are present in the sun's atmosphere. By careful study of these "fingerprints" we can tell how much of each element is present, the speed at which it is moving, the strength of any magnetic fields on the sun's surface, and the temperature of the surface of the sun.

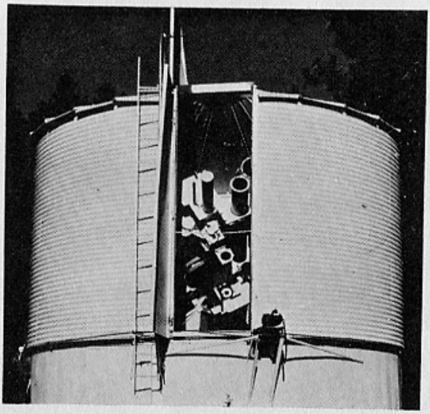
By direct photography through a simple telescope, often using special filters, we can study

many of the unusual activities on the sun, including flares, sunspots (cold areas) and plages (hot areas). Upon close examination we can see that the sun's surface has a "grainy" appearance, composed of columns of hot gas rising from and then sinking back into the surface.

The size of an astronomical telescope is measured by the diameter of its primary lens or mirror. The larger the primary lens or mirror, the greater is the light gathering power of the telescope, and the finer is the detail it can see. The largest telescope in the world is the 200-inch reflector at Mount Palomar, used for observing distant stars, nebulae, and galaxies. Since our sun is so much brighter than those objects, the telescopes here at Sacramento Peak need only relatively small primary lenses and mirrors. Because the solar instruments are small, several of them can be placed on the same mounting at one time. These mountings, called "spars", consist of a long hollow box that is kept pointed at the sun by means of an automatic guiding device.

MAIN LAB

The Main Lab houses the scientific and administrative offices of the observatory. This building is not open to visitors. Approximately one-third of the observatory employees work in the Main Lab. The research staff at Sacramento Peak consists of ten scientists, all specializing in some area of astrophysics. Scientists from other observatories and universities around the world come here to work with the research staff and to use the telescopes, and graduate students in astronomy work here during the summer.



The Grain Bin Dome contains telescopes that observe the solar corona.

GRAIN BIN DOME

AT THIS AND THE OTHER OBSERVING SITES VISITORS ARE ASKED NOT TO LEAVE THE ROAD OR WALKWAYS. JUST ONE PERSON WALKING ON THE GRASS CAN RAISE ENOUGH DUST TO DESTROY THE OBSERVATIONS BEING CONDUCTED.

Housed in an agriculture storage shed in 1949, the Grain Bin instrument was the first telescope installed here and only the second coronagraph station to be built in the Western Hemisphere. The spar in the Grain Bin carries two coronagraphs. A 4-inch-diameter instrument with a spectrograph analyzes the light from the corona and produces measurements of the absolute brightness of the corona. A second coronagraph with a 6-inch objective lens is used to take pictures of coronal shapes and motions once every minute. These films can then be run as time-lapse movies that speed up the activity by

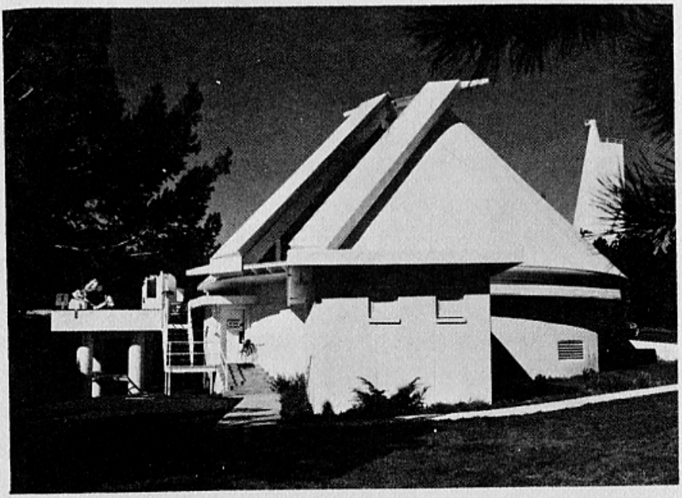
factors of 320 to 960 times. Many high-quality movies of the corona have been accumulated in the past two decades and are stored in a special fireproof vault in the Main Lab. They are the only such observations in the world and are used by scientists studying the corona.

BIG DOME

The Big Dome and the Tower Telescope represent the two major research facilities here. The Big Dome came into operation in 1952. In it we observe the surface (photosphere) and lower atmosphere (chromosphere) of the sun, and the overlying corona. PLEASE ENTER THE VISITORS' OBSERVATION ROOM, LOCATED ON THE LEFT (EAST) SIDE OF THE DOME.

Attached to the 26-foot spar are a number of separate telescopes. The largest is a 16-inch coronagraph housed in the large tube located on top of the spar. Light from this instrument is directed by a series of mirrors and lenses into an observing room located below and to the left of the telescope mounting. In the observing room, the actual work area of this dome, are spectrographs and other instruments for analyzing and photographing the sun. This particular coronagraph, the largest outside the Soviet Union, represents today's most powerful tool in the study of the corona.

On the near side of the spar is another large telescope operated jointly with the High Altitude Observatory of Boulder, Colorado. This instrument, called a coronal emission-line polarimeter, is also a coronagraph with a 16-inch lens. This specialized telescope is designed to measure the number of electrons present in the corona and the direction of

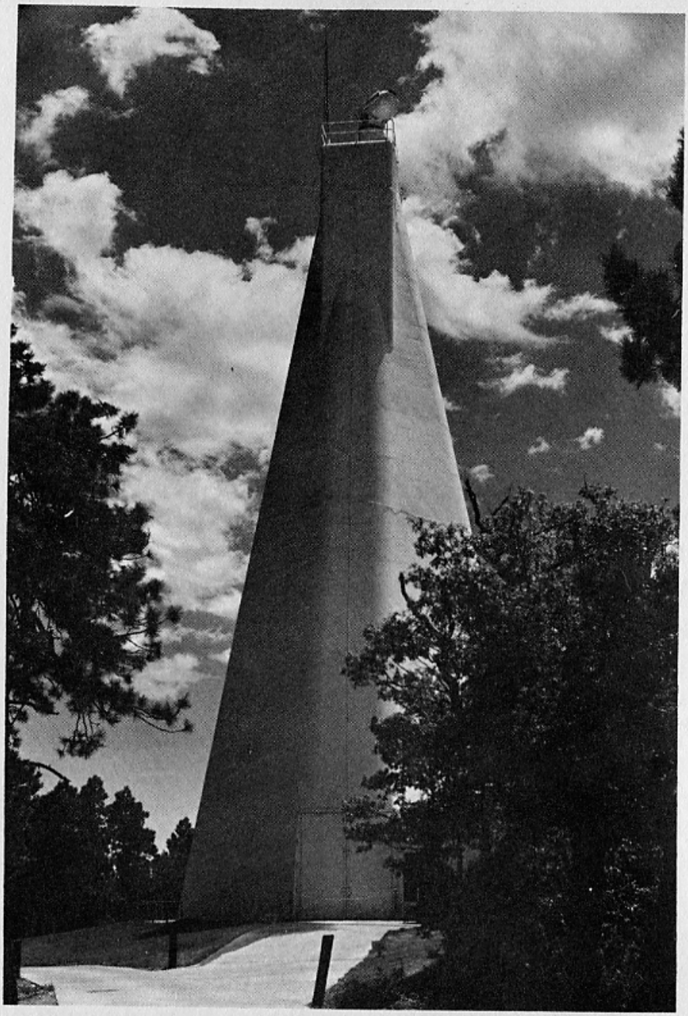


Big Dome

magnetic fields that penetrate into the corona from below. This instrument thus gives a three-dimensional picture of the complicated interaction between matter and magnetic fields in the corona. The small computer located behind the ladder along the wall to your left controls the polarimeter.

The magnetic fields on the sun's surface are measured and studied with an instrument called a magnetograph, attached to a 16-inch telescope. It is located on the far side of the spar, out of view. This instrument reveals intense magnetic fields in the region of sunspots, thousands of times stronger than the magnetic field of the earth. Rapid changes in these magnetic fields may be the source of the catastrophic flares that occur almost daily.

The dome of this facility rotates automatically to follow the sun. You may hear a bell that is rung automatically whenever the dome is turning. Most of the telescopes are controlled from the observing room below.



The Tower Telescope was built to allow observation of extremely small features on the surface of the sun.

TOWER TELESCOPE

WARNING: There is an open 220-foot-deep pit inside this building. Please stay outside the roped area and keep children under close supervision.

Enter the lobby through the glass front doors. The television monitor to your left shows a live, closed-circuit picture of the sun, taken with a telescope at the nearby Hilltop Dome. The door to the right of the television leads to the observing room. You may normally enter this room unless sensitive work is in progress. To the right of the observing room door is a cross sectional drawing of the Tower Telescope.

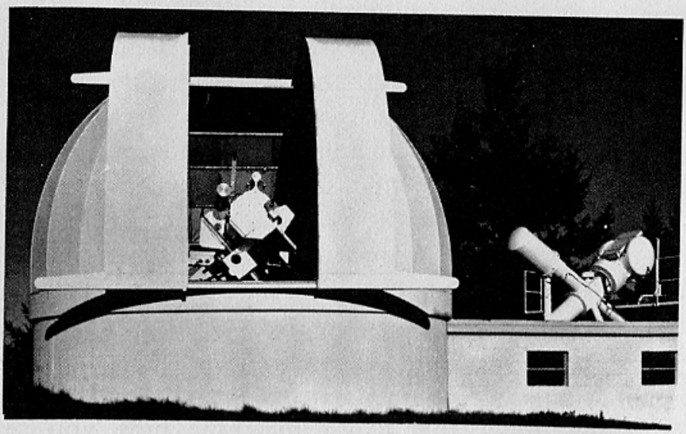
The Tower Telescope employs a new technique for obtaining a clear view of the sun. In most solar telescopes astronomers have the problem of sunlight heating the air in the telescope tube. This causes the air to move about in the tube and makes the image of the sun blur and change position. To eliminate this problem, all the air has been drawn out of the tube of the Tower Telescope, creating an almost total vacuum. When spectrographs or other instruments are used with the telescope, they too may be evacuated to create a nearly air-free optical path.

Sunlight enters the tower through a 30-inch window, 136 feet above ground level. By placing the window so high up, we avoid distortion of the solar image from local air turbulence near the ground. A pair of movable 44-inch mirrors is used to direct the sunlight down the 4-foot diameter tube you see running vertically down the center of the observing room. At 180 feet below the observing floor, the

sunlight strikes the concave 64-inch main mirror of the telescope. This mirror reflects the light beam back up the tube to the level where you now stand, producing an image of the sun 20 inches in diameter.

This telescope is designed to show extremely small features in the sun's photosphere and chromosphere that cannot be seen with most telescopes. The better we can see the sun and its finer details, the better we will be able to understand it.

The three vertical, 5-foot-diameter tubes clustered around the central tube extending through the ceiling contain spectrographs for analysis of the sunlight. By slightly tilting the main mirror at the bottom of the central tube, the sun's image can be focused on any of the spectrographs, or at three additional viewing ports around the central tube. The entire optical system, from the top of the tower to the bottom, including these spectrographs, the 40-foot-diameter observing room floor, and



Hilltop Dome and NASA Telescope

everything on it, is suspended near the top of the tower by a mercury bearing. The mercury bearing is in turn hung on three bolts, each only 3 inches in diameter. Though it is longer than a football field and weighs over 250 tons, the entire instrument is easily turned. For this reason, we ask you to stay outside the rope surrounding the central movable floor. The electronic equipment on the observing room floor controls the positioning and operation of the telescope, spectrographs, and other instruments through a small computer. An elevator running the full 350-foot length of the telescope is used for servicing the instruments. The building adjacent to the tower contains the offices, laboratories, and workshops connected with the operation of the Tower Telescope.

SCENIC VIEW

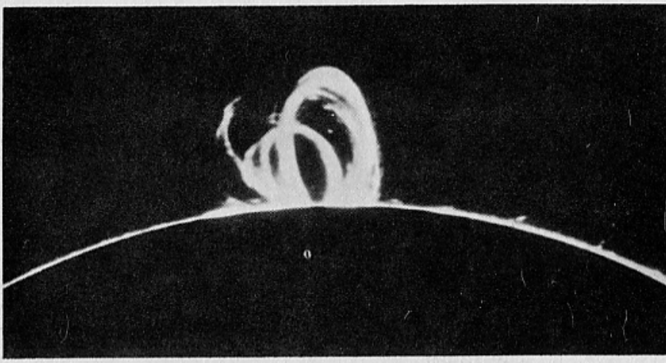
From here you have an excellent view of the Tularosa Basin and the San Andres and Organ Mountains, 50 miles to the southwest. The city of Alamogordo is hidden by the trees and hills to the northwest. Across the desert you can see Holloman Air Force Base and the southern end of the White Sands. El Paso is located near the distant mountains to your left.

The "searchlight" that you see here is actually a telescope designed to determine the amount of light-scattering particles (dust, smoke, etc.) in the atmosphere. It measures the brightness of a light shown vertically into the atmosphere from the desert below. This information is useful for determining the image quality to be expected by reconnaissance aircraft.

HILLTOP DOME

This dome, which is not open to visitors, contains several 4- to 8-inch telescopes for observing the solar surface and lower atmosphere. One of these telescopes and a television camera produces the television picture you saw in the lobby of the Tower Telescope. Other telescopes take pictures of sunspots, flares, etc., throughout the day to record all events occurring on the solar surface. The observations made here may be used to study flares. The cross-like telescope visible behind the dome is operated by NASA. It feeds light from the sun into a spectrograph, and the observations are used to support the operation of NASA satellites, space probes, etc.

This is the end of the self-guided tour. The visitors' parking lot is reached by continuing on the road downhill past the Hilltop Dome. We hope you have enjoyed your visit at Sacramento Peak Observatory. If you are interested in seeing more of the observatory, we welcome you to come back for the guided tour each Saturday at 2 P.M. (May through October only). That tour includes slides and a movie about the sun, and will give you the opportunity to ask questions of a member of the observatory staff. While you are here, we also hope you will enjoy the recreational and camping facilities of the Lincoln National Forest. There are no picnicking or camping facilities on the observatory grounds.



Solar material follows the loop-like outline of a strong magnetic field after a flare.

The Sun

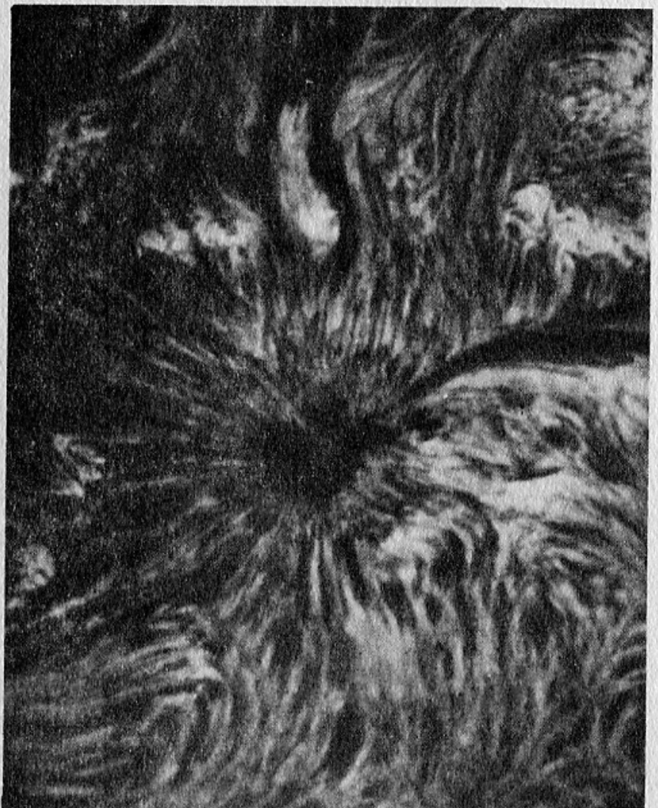
The sun is a very typical star of medium size and brightness. A globe of hot gas over one hundred times the diameter of the earth, the sun gets its energy by consuming four million tons of solar material per second. A continuous thermonuclear fusion process (similar to that produced for an instant in a hydrogen bomb) takes place at the sun's center. The surface temperature is about 10,000°F, except in sunspots where strong magnetic fields limit the temperature to about 6000°F. Even at the earth's distance of 93 million miles, the heat and light put out by the sun is impressive. The power falling on a square yard of the earth's surface is more than one thousand watts (over one horsepower) when the sun is directly overhead.

The chemical elements composing the sun are the same as those found on the earth: hydrogen, helium, oxygen, nitrogen, iron, etc., but in different

relative proportions. This has been determined by studying the light of the sun with a spectrograph, which spreads it out according to color (wavelength). In this spectrum each element makes its own imprint, which is the same in the laboratory on earth as it is in the sun.

The white "surface" of the sun is the top of an opaque cloudy layer that is disturbed in small areas by cool sunspots. These regions show many forms of vigorous activity, including solar flares. Above the white surface is a relatively transparent atmosphere that thins out with height through the chromosphere and corona, extending into space far beyond the earth. These outer layers are the only part of the sun that we can see, and they can be studied by several different means. At Sacramento Peak we use optical telescopes to observe the lower levels. Elsewhere, solar astronomers use radio telescopes, x-ray telescopes on rockets and space satellites, and space probes that actually sample the solar material streaming out past the earth in the "solar wind" together with sporadic bursts of particles from flares.

The study of the sun is important to us in many ways. We learn how the sun affects space surrounding the earth, a highly practical matter for any operations in space. It tells us a great deal about what the stars are like. The sun is a great cosmic laboratory also in which nature performs many exciting physical experiments on a scale impossible in any earthly laboratory.We thus can learn much of the basic information required in such developments as controlled thermonuclear power generation. On possibly a grander scale, finally, we perfect our knowledge of the origin and evolution of the universe in which we live.



This picture, taken with the Tower Telescope, greatly magnifies a region in the chromosphere surrounding a sunspot.

DEPARTMENT OF THE AIR FORCE

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES

AIR FORCE SYSTEMS COMMAND

SACRAMENTO PEAK OBSERVATORY

SUNSPOT, NEW MEXICO 88349